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Are Managers Punished for Crash Risk? Evidence from China *

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Abstract

This study examines how stock price crash risk affects subsequent managerial compensation and CEO dismissal rate. We find that managerial compensation significantly decreases and dismissal rate significantly increases following high crash risk, indicating that managers bear the negative consequences of high crash risk. Moreover, we find that the effects of crash risk are more pronounced for state-owned enterprises, after the split-share reform, and for firms located in provinces with higher levels of marketisation. Results from change regressions and an instrumental variable approach suggest that high crash risk causes changes in managerial compensation and dismissal rate, not vice versa. Finally, our evidence suggests that the punishment of managers for high crash risk is efficient in the sense that crash risk significantly decreases after CEO dismissal.

***Keywords*:** Crash Risk, Compensation, CEO Dismissal, Institutional Factors, Corporate Governance

Data Availability: Data used in this study are available from public sources identified in the paper.

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管理层会因为公司股价崩盘风险而受到处罚吗？—来自中国的经验证据

摘要

本文考察股价崩盘风险是否会影响公司管理层的薪酬和 CEO 被解雇概率。研究发现，伴随着高企的股价崩盘风险，管理层薪酬会显著降低，CEO 被解雇概率会显著提升，这意味着管理层承担了高股价崩盘风险的负面后果。进一步研究发现，股价崩盘风险的上述后果在公司为国有企业、完成股权分置改革后、地处市场化程度较高的省份时更显著。采用变化回归模型和工具变量方法的结果表明是股价崩盘风险导致管理层薪酬和 CEO 被解雇概率发生变化，而非相反。最后，本文还发现 CEO 被解雇后股价崩盘风险显著下降，表明因股价崩盘风险而处罚管理层的行为策略是有效的。

关键词：股价崩盘风险、薪酬、CEO 被解雇、制度因素、公司治理

I. Introduction

The global financial crisis in 2008 and the recent stock market turmoil in China have prompted considerable concern about the likelihood of abrupt, large-scale decline in a firm's stock price, or simply crash risk. A stock price crash brings about not only a substantial loss of shareholder wealth but also a drastic drop in investor confidence, imposing unusually high costs on shareholders as well as firms. In our sample, the average immediate loss in market value at the firm level caused by one crash event is about 13%.[2] Bollerslev and Todorov (2011) show that investors require risk premia to compensate for the jump tail risk. Cremers *et al.* (2015) document that an increase in jump factor loadings by two standard deviations is associated with a 3.5% to 5.1% decrease in expected annual stock returns.

Corporate managers have an incentive to hoard bad news and accelerate the release of good news: for instance, due to career concerns and incentive compensation based on short-term performance (e.g. Kothari *et al.*, 2009). Jin and Myers (JM, 2006) demonstrate that managerial incentives for bad news hoarding, along with information opaqueness, are a key driver behind a firm's stock price crash. Subsequent studies provide empirical evidence in support of the JM theory (e.g. Hutton *et al.*, 2009; Kim *et al.*, 2011a; Kim *et al.*, 2011b). These studies document significant associations of crash risk with (1) various firm-specific factors, including managerial opportunism in financial reporting (Hutton *et al.*, 2009; Kim and Zhang, 2013), accounting conservatism (Kim and Zhang, 2016), tax avoidance (Kim *et al.*, 2011a), debt covenant violation (Kim, Lin, Zhang and Zhang, 2016), deviation of cash flow rights from voting rights (Hong *et al.*, 2017), and financial statement comparability (Kim, Li, Lu and Yu, 2016); and (2) various individual manager-specific factors, including CEO versus CFO risk-taking incentives (Kim *et al.*, 2011b), CEO overconfidence (Kim, Wang and Zhang, 2016), and top executives' political ranks in China's state-owned enterprises (SOEs; Chen *et al.*, 2018).

A common feature of the aforementioned studies is the identification of firm-specific and/or manager-specific determinants of crash risk. To the best of our knowledge, however, previous research on crash risk has paid little attention to the consequences of crash risk, yet a stock price crash is an important event that triggers huge losses in investor and firm wealth and a sudden collapse in investor confidence. One can therefore ask the following unexplored questions: What would be the firm-level consequences of high crash risk? How does the firm or the market discipline managers who are prone to take actions that increase crash risk? What would be the possible remedial actions when managers allow high crash risk? Does the firm or the market punish managers who fail to constrain crash risk below a certain level? In emerging markets like China, what are the effective governance mechanisms that improve governance efficacy when traditional internal corporate

[2] This is the average weekly return for weeks with a return 3.2 standard deviations below the mean firm return during the fiscal year.

governance and investor legal protection are weak? Given the scarcity of empirical evidence on the intriguing questions above, this study aims to shed light on these issues.

Agency theory dictates that the principal should rely on low-cost and observable performance measures that can be mainly attributed to the agents when evaluating their performance (Hermalin and Weisbach, 1998; Holmstrom, 1979; Stroh *et al.*, 1996). To protect and maximise shareholders' wealth, executives need to be evaluated, compensated according to observable performance metrics, and replaced or terminated when their performance falls below a certain threshold. Given that a firm's crash risk is an important measurable attribute that critically affects shareholders' wealth, one can expect crash risk to be taken into account in executive compensation decisions and, in extreme cases, provide grounds for executive dismissal. This is because firm-specific crash risk (after netting out market-wide crash risk) is largely controllable by executives, and thus they should be held accountable for their failure to control crash risk—specifically by linking their compensation and dismissal to observable crash risk at the firm level. It is well established that stock performance, both the return level (first moment) and return volatility (second moment), plays a crucial role in managerial compensation awards and career outcomes (e.g. Core and Guay, 1999). To the best of our knowledge, however, prior research has paid little attention to the impact of extreme negative tail risk on return distribution (third moment) or stock price crash risk. As a result, little is known about the consequences of crash risk in terms of executive compensation and/or dismissal, although this negative tail risk has recently attracted much attention from investment strategists, academic researchers, and security market regulators.

To fill this void in the literature, our study investigates whether, and how, crash risk is associated with top executives' compensation as well as their dismissal or replacement. To do so, we use a sample of listed firms in China's stock market over the 16-year period of 1999 to 2014 for the following reasons. First, China's stock market has recently experienced stock price crashes at both the market and firm level, which has raised serious concerns about its stability and downside risk. Given the lack of empirical evidence on the consequences of crash risk, systematic evidence on the issue, based on a substantial sample from a large emerging market, is interesting to academia as well as the global investment community. Second, results from studies on corporate governance which are based on the assumption of dispersed ownership structure cannot easily be generalised to emerging markets such as China. China has special institutional factors, including state ownership, split-share structure reform, and marketisation levels, that serve a governance role in efficient compensation design and dismissal decisions related to crash risk. Exploration of whether, and how, these institutional governance mechanisms work is important in gaining a better understanding of corporate governance in emerging markets. Finally, given that China's stock market is the second largest in the world, empirical evidence from China on the issue is interesting in its own right and could provide useful insights into security market regulations for policymakers or regulators in other emerging markets.

To preview, the results of our main analyses reveal the following. First, we find that crash risk has a significantly negative association with the level of one-year-ahead compensation for top executives. We also find that crash risk in the current year significantly increases the likelihood of CEO turnover in the subsequent year. These results are consistent with the notion that top executives in China are punished for their failure to constrain crash risk below a certain threshold.

Second, we conduct analyses to better understand whether, and how, institutional factors influence the sensitivity of executive compensation and turnover to crash risk. Specifically, we find that the effect of crash risk is more pronounced for state-owned firms, which suggests that crash risk is costlier for the top executives of China's SOEs. We also find that the sensitivity of executive compensation and turnover to crash risk does increase in the period subsequent to the split-share structure reform.[3] This finding is consistent with the notion that the interests of original non-tradable shareholders are better aligned with those of tradable shareholders in the post-split-share-reform period, which contributes to improving the efficacy of corporate governance as reflected in the higher sensitivity of compensation and turnover to performance. Finally, we document that firms located in better (institutionally) developed provinces are more likely to punish their managers for failing to constrain crash risk below a certain level. Through exploring the variations in institutional and regulatory factors across different regions and time periods, we provide evidence that institutional infrastructure plays a role in improving firm-level governance.

Third, our findings are, overall, robust to a variety of sensitivity tests, including change regressions and an instrumental variable approach. The observed association between crash risk and the negative consequences for executives (i.e. lower compensation and higher turnover rate) is subject to the potential endogeneity concern that some unobservable factors associated with the crash risk may also drive boards' compensation and dismissal decisions. Although we control for fixed effects on firms in our main tests, we also adopt additional methodologies to alleviate concerns over the potential problems of correlated omitted variables and reverse causality. First, we conduct change regressions to further alleviate concerns about the aforementioned problems. In addition, we employ a two-stage least squares (2SLS) regression where the detrended average monthly stock turnover is used as the instrument in the first-stage regression. We find that the results of our level regressions

[3] Before the split-share structure reform, China's capital market had a two-tier share structure system, non-tradable shares and tradable shares, which created conflicts between controlling shareholders, who do not care about stock prices because they cannot trade at market price, and minority shareholders, who trade at market price (Firth *et al.*, 2010; Liao *et al.*, 2014). In 2005, the CSRC started the split-share structure reform, which allows holders of previously non-tradable shares to be able to trade after compensating minority shareholders in the form of cash, asset restructuring, warrants, and additional shares. By the end of 2007, 96% of firms had completed the split-share structure reform.

are robust to the use of alternative econometric methods (i.e. the change regression and the instrumental variable approach). Lastly, we examine the contemporaneous association between executive compensation and crash risk to further rule out the possibility of reverse causality. We fail to find any significant contemporaneous association between executive compensation and crash risk, which suggests that our main results are unlikely to be driven by reverse causality.

Finally, the results of our additional test show that our main results are robust to alternative measures of executive compensation. Also, we provide further evidence to suggest that the disciplinary punishments imposed on executives seem to be an efficient response on the part of the corporate board as crash risk significantly decreases in the period after their dismissal.

Our study makes several contributions to the literature. First, to the best of our knowledge, our study is the first to provide direct empirical evidence that public firms consider crash risk when evaluating executive performance and terminating poorly performing executives. Executives are punished in the form of lower compensation and even forced turnover in the period subsequent to high crash risk, suggesting that the board views the ability of top executives to control crash risk within an appropriate level as an important performance indicator.

Second, we extend and complement prior literature on crash risk by documenting the consequences of crash risk for corporate executives (rather than the determinants of crash risk) in the form of executive compensation and dismissal. While a growing body of research has examined firm-specific and/or manager-specific determinants of stock price crashes, it has paid little attention to the economic consequences of crashes.

Third, we contribute to the literature on corporate governance in a transitional economy with a concentrated ownership structure. The conventional standards for evaluating corporate governance systems are designed for economies with a dispersed ownership structure. Peng *et al.* (2008) point out that these standards are inappropriate for emerging economies with a concentrated ownership structure. We provide evidence in support of the governance role of particular institutional mechanisms, including state ownership, misalignment of cash flow rights and control rights, and marketisation, in executive compensation and performance evaluation in China. These institutional mechanisms are commonly seen in transition economies and markets under concentrated ownership. Therefore, our results also provide insights for markets beyond China.

Finally, we take advantage of the relatively simple compensation structure in Chinese firms to mitigate the reverse causality concern by excluding any *ex ante* influence of equity compensation on crash risk. Option-based compensation, which is the main compensation component that encourages executives to take excessive risks (Kim *et al*., 2011b), is seldom used in executive compensation in Chinese firms. By focusing on the responsiveness of overall *cash* compensation to crash risk, we provide direct evidence that managers are held accountable for crash risk.

II. Related Literature and Hypothesis Development

2.1 Crash Risk

Financial economists have long been interested in the market mechanisms that trigger crash risk. Extant literature has tried to explain market-wide crashes through leverage effects (Christie, 1982), volatility feedback (Campbell and Hentschel, 1992), bubble theories (Blanchard and Watson, 1982), hedging activities (Gennotte and Leland, 1990), and investor heterogeneity (Chen *et al.*, 2001; Hong and Stein, 1999). Short-sales constraints are commonly considered as the conditional assumption in investor heterogeneity theories (Hong and Stein, 2003).

At the firm level, bad news hoarding drives stock price crash risk, while information opacity is shown to facilitate bad news accumulation before the resultant stock price crashes (Bleck and Liu, 2007; DeFond *et al.*, 2015; Hutton *et al.*, 2009; Jin and Myers, 2006; Kim and Zhang, 2016; Kim *et al.*, 2016). DeFond *et al.* (2015) discuss how IFRS adoption influences the information transparency of financial and non-financial firms differently and find that IFRS adoption increases reporting transparency and decreases crash risk among non-financial firms only. In addition to institutional forces, a range of incentives and explanations for managerial bad news hoarding, and thus stock price crash risk, have been documented, including career concerns and compensation contracts (Kim *et al.*, 2011a; Kothari *et al.*, 2009), tax avoidance (Kim *et al.*, 2011b), excess perks (Xu *et al.*, 2014), and CEO overconfidence (Kim, Wang and Zhang, 2016). As mentioned in the preceding section, previous crash risk research has focused, in large part, on firm-specific or manager-specific attributes that cause firm-level crash risk.

To date, however, prior research has paid little attention to the *consequences* of high crash risk. Notable exceptions are the few studies that examine the influence of crash risk on asset pricing. Both Bollerslev and Todorov (2011) and Conrad *et al.* (2013) find that investors require compensation for crash risk. Cremers *et al.* (2015) document an economically significant drop in expected annual stock returns caused by increased jump risk. Eraker *et al.* (2003) study how jumps in stock returns, as well as jumps in return volatility, impact option pricing. All these results indicate that crashes are costly to both investors and firms. Surprisingly, however, little is known about whether, and to what extent, managers bear any negative consequences of crash risk and if they are punished for failing to constrain crash risk below a certain level.

2.2 Does Crash Risk Matter for Executive Compensation and Turnover?

Prior literature documents that various factors, including career concerns and compensation contracts, incentivise managers to withhold bad news or delay its disclosure (Kothari *et al*., 2009). However, managers cannot hoard or absorb bad news without limit. Once the amount of bad news accumulated over periods reaches a tipping point, the cost of bad news hoarding becomes greater than the associated benefit. Managers are then forced to release the accumulated hidden bad news all at once, thereby bringing about abrupt, large-scale decline in firm-specific returns or stock price crash (Jin and Myers, 2006).

The most important goal of an executive compensation contract is to protect shareholders' interests by aligning managerial interests with firm value. Stated another way, an efficient compensation contract can reward or punish management when shareholder wealth is created or destroyed, respectively. Moreover, to incentivise managers to maximise shareholders' wealth, poorly performing executives should be identified and dismissed when their performance or ability to create shareholder wealth falls below a certain threshold.

Stock price crash risk gives rise to a huge decline in shareholder wealth within a short time period and a loss of investor confidence in the long run. Unlike traditional volatility risk, which reflects managerial risk preference and is diversifiable through portfolio management, crash risk or extreme negative tail risk, which reflects managerial bad news hoarding and overinvestment, cannot be diversified away. Given that crash risk causes damage to firm value and that the likelihood of crash occurrence or simply crash risk is measurable, especially when firm-level crash risk can largely be attributed to managers' bad news hoarding behaviour,[4] we expect managerial compensation contracts to take into account managers' ability to control crash risk. Standard agency theory suggests that managerial compensation should be positively tied to firm value, and observable performance metrics that can be attributed to executives should be included in their performance evaluation as key performance indicators (Hermalin and Weisbach, 1998; Holmstrom, 1979; Stroh *et al*., 1996). Consistent with this theory, in addition to direct performance measures such as accounting performance and stock market returns, executive activities that potentially destroy firm value are also included in compensation contracts as part of the performance evaluation metrics. For example, executive compensation responds to missing earnings targets (Matsunaga and Park, 2001), internal control weaknesses (Hoitash *et al*., 2012), optimistic earnings forecasts (Otto, 2014), and so on. In a similar vein, managerial compensation is likely to reflect the cost (to shareholders and the firm) associated with stock price crash. To provide large-sample, systematic evidence on this unexplored question, we propose and test the following hypothesis in an alternative form:

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[4] We acknowledge the fact that crashes can also be caused by factors beyond managers' control, such as market-wide bubbles and short-sale constraints. In such cases, the crash risk is not indicative of executives' opportunistic behaviour or low ability. However, market-wide determinants of crash risk can hardly influence our results as we take out market-wide components in both measures of crash risk. There is still the possibility that other firm-specific factors beyond managerial control can cause crashes. We try to provide more insight on this issue in Section V.

H1a. Executive compensation in the current period is negatively associated with firms' crash risk in the previous year, all else being equal.

Given the extensive damage to firm value brought about by stock price crash at the firm level, the negative consequences of high crash risk on executives also applies to executives' career outcomes. Executives of low ability should be terminated in the interests of shareholders. If high crash risk serves as a signal of executives' inability or failure to control crash risk below the acceptable level, this third moment of return distribution should be included in the consideration of executive termination. An important prediction from the above discussion is that executives are more likely to be terminated subsequent to a period of high crash risk. To test the above prediction, we hypothesise in an alternative form:

H1b. Executives' turnover rate increases subsequent to years with a high crash risk, all else being equal.

2.3 Institutional Factors and Compensation Crash Risk Sensitivity

Executive compensation and dismissal are the two most important mechanisms that induce the efficacy of firm-level governance. The relevance of CEO succession decisions and the sensitivity of CEO personal wealth to shareholder wealth are significant predictors of firm performance (Zajac, 1990). In the standard principal-agent theory, the goal of corporate governance is to mitigate the conflicts between management and shareholders. Usually, the board of directors plays the role of setting CEO compensation, and Boyd (1994) shows that board control is an effective internal control mechanism in managerial compensation efficiency. However, in emerging markets such as China, where ownership is concentrated, the key conflicts are between controlling shareholders (often a family or the state) and minority shareholders (Tenev and Zhang, 2002). Ownership concentration has hindered the governance role of the board of directors (Hu *et al.*, 2010). The function of the board of directors tends to be service and resource acquisition, rather than control (Peng *et al.*, 2008). In the framework outlined by Cyert *et al.* (2002), when internal governance by the board is weak in imposing managerial control, external takeover threats become important. However, in economies with concentrated ownership, external takeovers are either rare or incur unusually high costs. Peng *et al.* (2008) point out that corporate governance research that is based on the assumption of dispersed ownership is inappropriate for emerging economies with concentrated ownership. Therefore, the incentives of controlling shareholders are of particular importance to the efficiency of compensation contract and dismissal decisions (i.e. the sensitivity of compensation to crash risk).

We start our analysis by focusing on state ownership, which is one form of controlling shareholder. Various forms of ownership, such as institutional ownership, family ownership, and the presence of large stockholders, have influences on CEO compensation (David *et al.*, 1998; Gomez-Mejia *et al.*, 1987; Gomez-Mejia *et al.*, 2003). In China, the government plays a prominent role in economic affairs and is listed by Child and Tse (2001) as the main institutional factor in China's transition that affects firms' operations. Therefore, we expect state ownership to be an important determinant of managerial compensation efficiency. Studies on Chinese firms' state ownership have frequently identified the consequences of inefficiency. For example, Yiu *et al.* (2005) show that endowed government resources do not help business groups to create a competitive edge. Both Bai *et al.* (2004) and Nee *et al.* (2007) find that state intervention in firms' governance tends to yield negative economic consequences. The adverse effects of state ownership, or the associated efficiency loss, is because state shareholders hold objectives at macro-economic and society level rather than focus on firms' value maximisation (Djankov, 1999).

However, in terms of crash risk, the interests of state shareholders are unclear compared with those of non-SOEs *ex ante*. On the one hand, maintaining stability is of high priority for the Chinese government. As Bai *et al.* (2006) point out, SOEs in China have played an important role in providing social stability at the expense of financial performance. Events such as stock price crashes can potentially bring about significant public concern and reputational damage to the government. In this sense, executives in SOEs are more likely to be punished than executives in non-SOEs for their inability or failure to constrain crash risk below a certain level. On the other hand, as mentioned above, the objectives for SOEs are multiple, such as providing employment, social stability, and tax revenue. The wealth damage caused by stock price crashes might be not the main concern for SOEs, while crash risk might be detrimental to the wealth of the controlling shareholders of non-SOEs. Moreover, SOEs are closely connected with the government, and compared to non-SOEs, they enjoy various preferential treatments from the government (Wang *et al.*, 2008; Zhang *et al.*, 2014), which makes them less attentive to capital market reactions. In this sense, executives in SOEs are less likely to be punished than executives in non-SOEs. Therefore, we hold no *a priori* expectation as to whether SOEs have a stronger executive compensation/turnover sensitivity to crash risk. So we do not state it explicitly as a hypothesis.

The second factor pointed out by Child and Tse (2001) that fundamentally altered the Chinese closed business system is the shifts in enterprise ownership. Misalignment of risk sharing and control rights results in severe within-firm agency conflicts. To examine how the within-firms agency problem impedes compensation efficiency, we consider the split-share structure reform in China, which effectively mitigates the agency problem between controlling shareholders and minority shareholders (Liao *et al.*, 2014; Liu and Tian, 2012) and facilitates risk-sharing between controlling insiders and minority shareholders (Li *et al.*, 2011). Before the reform, there were two categories of domestic A-shares (i.e. tradable and non-tradable shares). Non-tradable shareholders were usually controlling shareholders in non-SOEs and government agents in SOEs. The wealth of non-tradable shareholders did not fluctuate with stock price movement and thus these shareholders paid little attention to stock price. It has been argued that the two-tier share structure resulted in severe agency problems between the two classes of shareholders due to the misalignment of risk sharing and control rights (Wei and Geng, 2008). On 19 April 2005, the China Securities Regulatory Commission (CSRC) started the split-share structure reform, which allowed holders of previously non-tradable shares to trade their shares at market prices. To protect minority shareholders, before transferring to tradable shares, holders of non-tradable shares are required to compensate minority shareholders in the form of cash, asset restructuring, warrants, and additional shares. The compensation scheme can only pass when it is approved by at least two-thirds of the tradable shareholders (Firth *et al*., 2010; Li *et al.*, 2011). A total of 234 firms completed the reform in 2005, 908 firms in 2006, and 118 firms in 2007. By the end of 2007, 96% of firms completed the split-share structure reform (Li *et al.*, 2017) and transferred their non-tradable shares into tradable shares.

Since the reform, the wealth of the original non-tradable shareholders co-moves with the stock price, which means they also suffer from stock price crashes. Compared to before the reform, when stock price crashes had no direct impact on their wealth, large (previously non-tradable) shareholders are now more likely to take actions to prevent high crash risk. Therefore, we expect that managerial compensation and dismissal rates become more sensitive to crash risk in the post-reform period, as controlling shareholders begin to play monitoring roles to control crash risk. Specifically, we present the following hypothesis:

H2a. Executive compensation/turnover sensitivity to crash risk is higher after the split-share structure reform than before the reform.

Finally, we consider the degree of marketisation in the provinces where the firm is headquartered. Prior studies show that institutional factors, such as investor rights protection and legal enforcements, play an important role in determining firm-level governance efficacy (LaPorta *et al.*, 1998; Leuz *et al.*, 2003). Legal protection of minority investors is generally poor in China (Allen *et al.*, 2005; Brockman and Chung, 2003; Morck *et al.*, 2000). However, there is a significant variation in institutional development across provinces or regions within China. Therefore, even in the same country, listed firms operate within different institutional environments. Firms in more developed provinces operate in a business environment of higher marketisation and better legal enforcement, particularly because market development requires a legal system that serves the market well and is accompanied by strong enforcement mechanisms (Kafouros *et al.*, 2012). Child and Tse (2001) note the development in business support systems, which include legal, accounting, and finance systems, the third institutional sphere related to Chinese firms' operation. We therefore expect that firms located in more developed markets are more responsive to the capital market. Specifically, we predict that managerial compensation and dismissal rates become more sensitive to crash risk in the post-reform period. This leads us to propose and test the following hypothesis:

H2b. Executive compensation/turnover sensitivity to crash risk is higher for firms located in provinces with high marketisation than for firms located in provinces with low marketisation.

III. Sample and Variable Construction

3.1 Sample

Since 1998, listed companies in China have been required to disclose the top three executive cash compensations in their annual reports, and the compensation data have been available from the China Stock Market and Accounting Research (CSMAR) database since 1999. Our sample period therefore starts from 1999, and our initial sample consists of all listed companies traded on the Shanghai Stock Exchange and the Shenzhen Stock Exchange from 1999 to 2014. From the initial 24,725 observations, we delete (1) 303 observations from the financial industry, due to the different nature of operations and strict government regulation of this industry; and (2) 2,644 observations that lacked data for any variable used in the compensation models. We further exclude the first year and the turnover year of executives (4,501 observations) because compensation in those years may include signing bonuses or retirement/severance packages (Wang 2010). Our final sample consists of 2,514 unique firms with 17,277 firm-year observations. The exact number of observations used in our regression analysis varies depending on the data requirement for the variables included in the regressions.

3.2 Measuring Firm-Specific Crash Risk

The variable of interest is firm-specific crash risk, not market-wide crash risk. Following prior studies (Chen *et al.*, 2001; Kim *et al.*, 2011a, 2011b), we construct two measures of crash risk. The first is the negative conditional return skewness (*NCSKEW*), computed by taking negative of the third moment of firm-specific weekly returns (after netting the market-wide component) for each sample year and dividing it by the standard deviation of firm-specific weekly returns raised to the third power. The firm-specific weekly return is defined as the natural logarithm of one plus the residual return from the expanded market model regression, including the lead and lag returns for the market index return.

Our second measure is the down-to-up volatility (*DUVOL*) measure of crash likelihood, which is computed as follows: For firm *j* over a fiscal year period, each week is classified as an "up" ("down") week if the firm-specific weekly return is above (below) the annual mean. Then, we calculate the standard deviation, separately, for each "up" and "down" subsample. The *DUVOL* measure is the natural logarithm of the ratio of the standard deviation of the "down" weeks to that of the "up" weeks. Details of the construction of the variables can be found in Hutton *et al.* (2009) and Kim *et al.* (2011a).

In Panel A of Table 1, the first two columns provide the sample distribution and mean of the two crash risk measures by year. The means of *NCSKEW* and *DUVOL* in our sample are -0.234 and -0.161, respectively, which are comparable in magnitude to those reported in prior studies focusing on the Chinese market (e.g. Xu *et al.*, 2014). In Panel B of Table 1, the first two columns report the mean of the two crash risk measures by industry. The textiles (communications) industry has the highest (lowest) crash risk for both crash risk measures.

Besides the crash risk measures, we also report executive dismissal and turnover rates by year and industry in panels A and B, respectively, of Table 1. In Table 1 and throughout the study, we differentiate between executive dismissal and turnover as follows. The indicator variable, *DISMISSAL*, equals 1 if the stated reason for executive departure is dismissal, litigation, personal reasons, or retirement before 60 or if no reason is provided, and 0 otherwise (e.g. Chang and Wong, 2009). The indicator variable, *TURNOVER*, equals 1 if executives leave the company for whatever reason and 0 otherwise. As shown in panels A and B, in our sample, the average dismissal rate is 8.60%, while the average turnover rate is 17%. As shown in Panel A, the dismissal rate ranges from a lowest of 3.2% in 2014 to a highest of 14.5% in 2007 and a second highest of 13.8% in 2008, suggesting that the dismissal rate for executives in Chinese listed firms was highest during the 2007–2008 financial crisis. As shown in Panel B, the dismissal rate differs across different industries, ranging from a lowest of 5.6% in the electronics industry to a highest of 12.9% in the utilities industry. As expected, in both panels, the turnover rate is higher than the dismissal rate because executives departed the firms for reasons other than dismissal.

Table 1 Sample Distribution and Descriptive Statistics for Crash Risk

Panel A: Sample distribution and crash risk across years

Year	*NCSKEW*	*DUVOL*	*DISMISSAL*	*TURNOVER*	*N*
1999	-0.159	-0.082	0.118	0.239	322
2000	-0.449	-0.352	0.128	0.232	478
2001	-0.118	-0.127	0.122	0.242	797
2002	0.034	-0.002	0.098	0.214	758
2003	0.289	0.315	0.123	0.207	778
2004	0.017	0.070	0.116	0.228	864
2005	0.051	0.060	0.117	0.224	879
2006	-0.204	-0.058	0.102	0.206	882
2007	-0.282	-0.222	0.145	0.202	928
2008	-0.195	-0.182	0.138	0.185	962
2009	-0.656	-0.545	0.110	0.182	1052
2010	-0.303	-0.283	0.073	0.189	1052
2011	-0.051	-0.009	0.059	0.145	1325
2012	-0.231	-0.119	0.051	0.124	2014
2013	-0.578	-0.443	0.058	0.140	2129
2014	-0.287	-0.171	0.032	0.078	2051
Mean	-0.234	-0.161	0.086	0.170	

Panel B: Sample distribution and crash risk across industries

Industry	*NCSKEW*	*DUVOL*	*DISMISSAL*	*TURNOVER*	*N*
Agriculture and fishery	-0.205	-0.078	0.087	0.175	331
Mining	-0.300	-0.201	0.127	0.221	385
Food/beverage	-0.145	-0.103	0.070	0.168	739
Textiles	-0.129	-0.071	0.063	0.142	684
Paper/Printing	-0.219	-0.156	0.082	0.147	341
Petroleum	-0.165	-0.121	0.095	0.179	1867
Electronic	-0.262	-0.182	0.056	0.119	809
Metal/Non-metal	-0.306	-0.202	0.091	0.183	1511
Machines	-0.263	-0.192	0.080	0.158	3071
Pharmaceutical	-0.160	-0.127	0.062	0.138	1134
Furniture/others	-0.230	-0.161	0.036	0.088	249
Utilities	-0.240	-0.168	0.129	0.244	651
Construction	-0.315	-0.218	0.100	0.191	320
Transportation and logistics	-0.283	-0.175	0.109	0.202	687
Information technology	-0.313	-0.207	0.067	0.134	1136
Wholesales and retails	-0.160	-0.104	0.099	0.201	1106
Real estate	-0.232	-0.156	0.095	0.176	980
Service	-0.211	-0.146	0.091	0.177	503
Communication	-0.414	-0.343	0.069	0.172	116
Others	-0.292	-0.214	0.123	0.212	651
Mean	-0.234	-0.161	0.086	0.170	

N = 17,277 firm-years

3.3 Measuring Managerial Compensation

Following previous studies focusing on China (e.g. Conyon and He, 2011; Firth *et al.*, 2006b), we measure managerial compensation by taking the natural logarithm of the average annual cash compensation for the top three highest paid executives. We consider only the cash compensation, which consists of base salary, bonuses, and commissions, because stock options are rarely used in China. For robustness checks, we also separately examine the compensation sensitivity of the CEO and CFO, who are commonly among the top three highest paid executives in a firm. The results are discussed in Section 5.5.

IV. Empirical Analysis

4.1 Crash Risk and Executive Compensation (H1a)

To examine the influence of crash risk on executive compensation (H1a), we estimate the following regression which has been popularly used in prior compensation studies (e.g. Conyon and He, 2011; Firth *et al.*, 2006b; Wang, 2010):

$$
\begin{aligned}
LNCOMP_t = {} & \alpha+\beta_1 CRASHRISK_{t-1}+\gamma_1 LNSALE_t+\gamma_2 LEV_t+\gamma_3 BM_t+\gamma_4 PRIVATE_t \\
& +\gamma_5 OWNER_t+\gamma_6 FOREIGN_t+\gamma_7 DUAL_t+\gamma_8 INDEP_t \\
& +\gamma_9 LNFIRMAGE_t+\gamma_{10} GEO_t+\gamma_{11} ROA\_IND_t+\gamma_{12} RET\_IND_t \\
& +\gamma_{13} VOLATILITY_{t-1}+\sum \delta YearDummy+\sum \kappa IndustryDummy+\varepsilon_t, \qquad (1)
\end{aligned}
$$

where *LNCOMP* is the natural logarithm of average annual cash compensation for the top three highest paid executives. In robustness tests, we also use the natural logarithm of average annual cash compensation for the CEO (*LNCOMP_CEO*) and CFO (*LNCOMP_CFO*) as alternative compensation measures. *CRASHRISK* is one of the two crash risk measures (*NCSKEW* and *DUVOL*) defined earlier. Following previous literature (e.g. Conyon and He, 2011; Firth *et al.*, 2006b; Wang, 2010), we control for sales (*LNSALE*), leverage ratio (*LEV*), book-to-market ratio (*BM*), state-owned status (*PRIVATE*), ownership structure (*OWNER*), issuance of H-shares or B-shares (*FOREIGN*), CEO duality (*DUAL*), board independence (*INDEP*), firm age (*LNFIRMAGE*), provincial marketisation (*GEO*), and industry-adjusted return on assets (*ROA_IND*). Lastly, we include the first moment and second moment of stock return, that is, industry adjusted stock return (*RET_IND*) and return volatility (*VOLATILITY*), as we are studying a higher moment of return distribution. Detailed definitions of all the variables used in regressions are provided in the Appendix.

Panel A of Table 2 reports summary statistics of the variables used in Eq. (1), while Panel B reports the pair-wise Pearson correlation matrix. *LNCOMP* is negatively correlated with both measures of crash risk (*NCSKEW* and *DUVOL*), and the correlations are both significant at the 1% level. While only indicative of the underlying relation, this negative correlation is in line with the prediction in H1a.

Columns 1 and 2 in Panel C of Table 2 present the results of regressions in Eq. (1), with *NCSKEW* and *DUVOL* as proxies for crash risk, respectively. As shown in columns 1 and 2, we find that the coefficients of both measures of crash risk are negative and highly significant (-0.021 with p = 0.000 and -0.028 with p = 0.000, respectively). These results suggest that a one-standard-deviation increase in firm-specific crash risk leads to a reduction of 2.1% to 2.3% in the natural logarithm of CEO compensation. The finding is consistent with H1a, suggesting that higher crash risk in the current year is associated with lower executive compensation in the following year.

In an effort to alleviate concerns over problems of correlated (time-invariant) omitted variables and potential endogeneity, we re-estimate Eq. (1) after including firm fixed effects. The results are reported in columns 3 and 4 of Table 2. Overall, we find that the regressions with firm fixed effects are qualitatively identical to those in columns 1 and 2. In short, the results reported in Panel C of Table 2 are consistent with our hypothesis that executive compensation decreases following the high crash year, which suggests that managers are punished in the form of a pay cut for their failure to constrain crash risk below a certain level. The coefficients of the control variables, wherever statistically significant, are consistent with our prior results and the results reported in prior studies (e.g. Conyon and He, 2011; Firth *et al.*, 2006b; Wang, 2010).

Table 2 Crash Risk and Managerial Compensation

Panel A: Descriptive statistics

Variable	Mean	SD	p25	p50	p75	*N*
$LNCOMP_t$	12.42	1.014	11.80	12.55	13.13	17,277
$NCSKEW_{t-1}$	-0.225	0.980	-0.835	-0.220	0.398	17,221
$DUVOL_{t-1}$	-0.159	0.814	-0.696	-0.178	0.371	17,184
$LNSALE_t$	20.91	1.483	19.96	20.83	21.77	17,277
LEV_t	0.478	0.231	0.315	0.476	0.623	17,277
BM_t	0.437	0.299	0.231	0.377	0.572	17,277
$PRIVATE_t$	0.447	0.497	0.000	0.000	1.000	17,277
$OWNER_t$	0.384	0.162	0.256	0.367	0.505	17,277
$FOREIGN_t$	0.090	0.286	0.000	0.000	0.000	17,277
$DUAL_t$	0.156	0.363	0.000	0.000	0.000	17,277
$INDEP_t$	0.325	0.116	0.333	0.333	0.375	17,277
$LNFIRMAGE_t$	2.005	0.670	1.386	2.079	2.565	17,277
GEO_t	1.988	0.310	1.824	2.102	2.237	17,277
ROA_IND_t	-0.002	0.056	-0.026	-0.000	0.026	17,277
RET_IND_t	0.096	0.502	-0.140	0.004	0.218	17,277
$VOLATILITY_{t-1}$	0.125	0.102	0.086	0.112	0.147	17,277

Panel B: Pearson correlation matrix

	$LNCOMP_t$	$NCSKEW_{t-1}$	$DUVOL_{t-1}$	$LNSALE_t$	LEV_t	BM_t
$LNCOMP_t$	1					
$NCSKEW_{t-1}$	-0.078***	1				
$DUVOL_{t-1}$	-0.078***	0.924***	1			
$LNSALE_t$	0.482***	-0.059***	-0.062***	1		
LEV_t	-0.052***	0.030***	0.037***	0.188***	1	
BM_t	0.136***	0.103***	0.137***	0.372***	-0.065***	1
$PRIVATE_t$	0.121***	-0.014*	-0.020***	-0.223***	0.149***	-0.160***
$OWNER_t$	-0.060***	-0.014*	-0.008	0.199***	-0.059***	0.094***
$FOREIGN_t$	0.085***	-0.029***	-0.023***	0.175***	0.087***	0.237***
$DUAL_t$	0.158***	-0.020***	-0.019	-0.070***	-0.121***	-0.075***
$INDEP_t$	0.488***	0.018	0.032***	0.198***	0.028***	0.139***
$LNFIRMAGE_t$	0.200***	-0.057***	-0.047***	0.201***	0.342***	0.066***
GEO_t	0.454***	-0.026***	-0.017***	0.170***	-0.052***	0.090***
ROA_IND_t	0.235***	-0.084***	-0.110***	0.288***	-0.325***	0.004
RET_IND_t	0.009	-0.006	0.002	-0.016**	-0.016**	-0.088***
$VOLATILITY_{t-1}$	0.035***	-0.213***	-0.212***	-0.029***	0.074***	-0.112***

	$PRIVATE_t$	$OWNER_t$	$FOREIGN_t$	$DUAL_t$	$INDEP_t$
$PRIVATE_t$	1				
$OWNER_t$	-0.211***	1			
$FOREIGN_t$	-0.143***	0.034***	1		
$DUAL_t$	0.261***	-0.071***	-0.051***	1	
$INDEP_t$	0.173***	-0.062***	-0.010	0.172***	1
$LNFIRMAGE_t$	-0.220***	-0.203***	0.154***	-0.120***	0.199***
GEO_t	0.185***	-0.031***	0.130***	0.156***	0.359***
ROA_IND_t	0.055***	0.139***	-0.052***	0.014*	0.025***
RET_IND_t	0.045***	-0.002	-0.011	0.032***	0.011
$VOLATILITY_{t-1}$	0.040***	-0.025***	0.005	0.013*	0.039***

	$LNFIRMAGE_t$	GEO_t	ROA_IND_t	RET_IND_t	$VOLATILITY_{t-1}$
$LNFIRMAGE_t$	1				
GEO_t	0.086***	1			
ROA_IND_t	-0.160***	0.075***	1		
RET_IND_t	-0.032***	0.023***	0.066***	1	
$VOLATILITY_{t-1}$	0.128***	0.018**	-0.037***	-0.009	1

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$ (two-tailed tests).

Panel C: Regression results of compensation				
	(1)	(2)	(3)	(4)
Dependent Variable	$LNCOMP_t$	$LNCOMP_t$	$LNCOMP_t$	$LNCOMP_t$
Crash Risk Variable	*NCSKEW*	*DUVOL*	*NCSKEW*	*DUVOL*
$CRASHRISK_{t-1}$	-0.021***	-0.028***	-0.017***	-0.021***
	(0.000)	(0.000)	(0.000)	(0.000)
$LNSALE_t$	0.272***	0.271***	0.226***	0.226***
	(0.000)	(0.000)	(0.000)	(0.000)
LEV_t	-0.427***	-0.424***	-0.286***	-0.283***
	(0.000)	(0.000)	(0.000)	(0.000)
BM_t	-0.304***	-0.298***	-0.221***	-0.217***
	(0.000)	(0.000)	(0.000)	(0.000)
$PRIVATE_t$	0.050*	0.049*	0.104**	0.104**
	(0.060)	(0.065)	(0.013)	(0.014)
$OWNER_t$	-0.531***	-0.533***	-0.175*	-0.172*
	(0.000)	(0.000)	(0.062)	(0.067)
$FOREIGN_t$	0.186***	0.185***	0.374	0.373
	(0.000)	(0.000)	(0.271)	(0.273)
$DUAL_t$	0.094***	0.094***	0.037	0.037
	(0.000)	(0.000)	(0.106)	(0.113)
$INDEP_t$	0.257**	0.274**	0.349***	0.361***
	(0.020)	(0.013)	(0.000)	(0.000)
$LNFIRMAGE_t$	0.019	0.019	0.384***	0.387***
	(0.229)	(0.218)	(0.000)	(0.000)
GEO_t	0.517***	0.518***	0.335**	0.332**
	(0.000)	(0.000)	(0.013)	(0.013)
ROA_IND_t	1.374***	1.370***	0.808***	0.800***
	(0.000)	(0.000)	(0.000)	(0.000)
RET_IND_t	-0.008	-0.008	-0.023***	-0.022***
	(0.346)	(0.394)	(0.001)	(0.003)
$VOLATILITY_{t-1}$	0.120*	0.127	-0.021	0.003
	(0.076)	(0.102)	(0.649)	(0.956)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	No	No
Firm fixed effects	No	No	Yes	Yes
adj. R^2	0.612	0.613	0.668	0.669
N	17,209	17,172	17,209	17,172

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (two-tailed tests); p-values based on standard errors clustered by firm are displayed in parentheses.

4.2 Crash Risk and CEO Dismissal (H1b)

To examine the impact of crash risk on executive dismissal, we estimate the logit regression in Eq. (2) below, which links the likelihood of executive dismissal in the next year with crash risk in the current year. Our choice of control variables is guided by prior related studies (e.g. Firth *et al.*, 2006a; Hill and Phan, 1991; Kato and Long, 2006; Wang, 2010):

$$\begin{aligned} Prob(DISMISSAL=1)_t = {} & \alpha+\beta_1 CRASHRISK_{t-1}+\gamma_1 LNSALE_{t-1}+\gamma_2 LEV_{t-1} \\ & +\gamma_3 PRIVATE_{t-1}+\gamma_4 OWNER_{t-1}+\gamma_5 FOREIGN_{t-1} \\ & +\gamma_6 DUAL_{t-1}+\gamma_7 INDEP_{t-1}+\gamma_8 LNFIRMAGE_{t-1} \\ & +\gamma_9 LNCEOAGE_{t-1}+\gamma_{10} LNCEOTENURE_{t-1} \\ & +\gamma_{11} CEOSHARE_{t-1}+\gamma_{12} GEO_{t-1}+\gamma_{13} ROA\_IND_{t-1} \\ & +\gamma_{14} RET\_IND_{t-1}+\gamma_{15} VOLATILITY_{t-1} \\ & +\sum \delta YearDummy+\sum \kappa IndustryDummy+\varepsilon, \end{aligned} \tag{2}$$

where Prob (*DISMISSAL = 1)* is an *ex ante* likelihood of CEO dismissal, which is *ex post* coded 1 if there is forced CEO turnover and 0 otherwise. Following Chang and Wong (2009), CEO turnover is considered as forced turnover if the stated turnover reason is dismissal, litigation, personal reasons, or retirement before 60 or if no reason is provided.[5] In addition to the firm characteristics controlled in Eq. (1), we also control for CEO age (*LNCEOAGE*), CEO tenure (*LNCEOTENURE*), industry-adjusted return on assets (*ROA_IND*), and industry-adjusted stock return (*RET_IND*). Detailed definitions of the variables are provided in the Appendix.

The summary statistics are reported in Panel A of Table 3, while the Pearson correlation matrix is reported in Panel B of Table 3. As shown in Panel A, the average dismissal rate (*DISMISS*) is 8.6%, while the turnover rate (*TURNOVER*) is 17%, which is higher than the dismissal rate. As shown in Panel B, both *DISMISSAL* and *TURNOVER* are positively associated with the two crash risk measures, *NCSKEW* and *DUVOL*, significant at the 1% level.

Panel C of Table 3 reports the results of logit regressions in Eq. (2), with the dependent variable being *PROB(DISIMSSAL=1)* in columns 1 and 2 and *PROB(TURNOVER=1)* in columns 3 and 4. As shown in columns 1 and 2, the estimated coefficients of *NCSKEW* and *DUVOL* are 0.098 and 0.134, respectively, both significant at the 5% level. The marginal effect of crash risk in column 1 (2) is 0.61% (0.67%), which translates into a 7.1% (7.8%) increase in the average dismissal rate (8.6%) when crash risk increases by one standard deviation around the mean (at the mean value of all other variables). This is consistent with H1b, suggesting that CEOs are more likely to be dismissed when the crash risk is higher.

[5] The reasons for CEO turnovers in China are usually not disclosed in detail. Personal reasons and retirement are the mostly commonly used excuses. For robustness, we construct an indicator, *RETIRE*, which equals 1 for CEO turnovers for reasons such as normal retirement and expected leave after the expiration of a pre-set term. We re-do Eq. (2) by replacing the dependent variable with *RETIRE*. We find no significant association between crash risk and *RETIRE*, suggesting that crash risk is unrelated with CEO's normal retirement and expected leave.

In columns 3 and 4, we use, as the dependent variable, the likelihood of CEO turnover, *PROB(TURNOVER=1)*, which is *ex post* coded 1 if the CEO departs the firm for whatever reason and 0 otherwise. As shown in the last two columns, the results using *PROB(TURNOVER=1)* are qualitatively identical to those using *PROB(DISMISSAL=1)* in the first two columns. In short, the results presented in Panel C of Table 3 are consistent with H1b, indicating that executives are punished for their inability or failure to control high crash risk in the form of greater likelihood of dismissal or replacement in the years subsequent to high crash risk.

Table 3 Crash Risk and CEO Dismissal

Panel A: Descriptive statistics

Variable	Mean	SD	p25	p50	p75	N
$DISMISSAL_t$	0.086	0.281	0.000	0.000	0.000	17,277
$TURNOVER_t$	0.170	0.376	0.000	0.000	0.000	17,277
$NCSKEW_{t-1}$	-0.234	0.976	-0.827	-0.223	0.400	17,271
$DUVOL_{t-1}$	-0.161	0.796	-0.684	-0.180	0.365	17,271
$LNSALE_{t-1}$	20.91	1.483	19.96	20.83	21.77	17,277
LEV_{t-1}	0.478	0.231	0.315	0.476	0.623	17,277
$PRIVATE_{t-1}$	0.447	0.497	0.000	0.000	1.000	17,277
$OWNER_{t-1}$	0.384	0.162	0.256	0.367	0.505	17,277
$FOREIGN_{t-1}$	0.090	0.286	0.000	0.000	0.000	17,277
$DUAL_{t-1}$	0.156	0.363	0.000	0.000	0.000	17,277
$INDEP_{t-1}$	0.325	0.116	0.333	0.333	0.375	17,277
$LNFIRMAGE_{t-1}$	2.005	0.670	1.386	2.079	2.565	17,277
$LNCEOAGE_{t-1}$	3.937	0.139	3.850	3.932	4.043	11,840
$LNCEOTENURE_{t-1}$	1.324	0.581	0.693	1.099	1.792	12,951
$CEOSHARE_{t-1}$	0.037	0.105	0.000	0.000	0.000	17,277
GEO_{t-1}	1.988	0.310	1.824	2.102	2.237	17,277
ROA_IND_{t-1}	-0.002	0.056	-0.026	-0.000	0.026	17,277
RET_IND_{t-1}	0.096	0.502	-0.140	0.004	0.218	17,277
$VOLATILITY_{t-1}$	0.125	0.078	0.088	0.112	0.148	17,277

Panel B: Pearson correlation matrix among the compensation and variables

	$DISMISSAL_t$	$TURNOVER_t$	$NCSKEW_{t-1}$	$DUVOL_{t-1}$	$LNSALE_{t-1}$
$DISMISSAL_t$	1				
$TURNOVER_t$	0.679***	1			
$NCSKEW_{t-1}$	0.028***	0.029***	1		
$DUVOL_{t-1}$	0.028***	0.034***	0.925***	1	
$LNSALE_{t-1}$	-0.050***	-0.046***	-0.048***	-0.049***	1
LEV_{t-1}	0.090***	0.113***	0.041***	0.043***	0.188***
$PRIVATE_{t-1}$	-0.096***	-0.130***	-0.024***	-0.027***	-0.223***
$OWNER_{t-1}$	-0.004	-0.006	-0.001	0.004	0.199***
$FOREIGN_{t-1}$	0.016**	0.029*	-0.033***	-0.025***	0.175***
$DUAL_{t-1}$	-0.082***	-0.121***	-0.032***	-0.034***	-0.070***
$INDEP_{t-1}$	-0.050***	-0.083***	-0.034***	-0.022***	0.198***
$LNFIRMAGE_{t-1}$	0.069***	0.098***	-0.037***	-0.034***	0.201***
$LNCEOAGE_{t-1}$	-0.077***	0.042***	-0.013*	0.002	0.194***
$LNCEOTENURE_{t-1}$	-0.052***	0.026***	-0.055***	-0.038***	0.107***
$CEOSHARE_{t-1}$	-0.094***	-0.130***	-0.054***	-0.058***	-0.094***
GEO_{t-1}	-0.059***	-0.058***	-0.063***	-0.055***	0.170***
ROA_IND_{t-1}	-0.119***	-0.139***	-0.077***	-0.106***	0.288***
RET_IND_{t-1}	-0.026***	-0.023***	-0.280***	-0.332***	-0.016*
$VOLATILITY_{t-1}$	0.039***	0.017**	-0.221***	-0.232***	-0.054***

	LEV_{t-1}	$PRIVATE_{t-1}$	$OWNER_{t-1}$	$FOREIGN_{t-1}$	$DUAL_{t-1}$
LEV_{t-1}	1				
$PRIVATE_{t-1}$	-0.149***	1			
$OWNER_{t-1}$	-0.059***	-0.211***	1		
$FOREIGN_{t-1}$	0.087***	-0.143***	0.034***	1	
$DUAL_{t-1}$	-0.121***	0.261***	-0.071***	-0.051***	1
$INDEP_{t-1}$	0.028***	0.173***	-0.062***	-0.010	0.172***
$LNFIRMAGE_{t-1}$	0.342***	-0.220***	-0.203***	0.154***	-0.120***
$LNCEOAGE_{t-1}$	-0.055***	-0.078***	0.050***	0.079***	-0.117***
$LNCEOTENURE_{t-1}$	-0.120***	0.186***	-0.042***	-0.027***	0.128***
$CEOSHARE_{t-1}$	-0.261***	0.386***	0.024***	-0.104***	0.301***
GEO_{t-1}	-0.052***	0.185***	-0.031***	0.130***	0.156***
ROA_IND_{t-1}	-0.325***	0.055***	0.139***	-0.052***	0.014
RET_IND_{t-1}	-0.016*	0.045***	-0.002	-0.011	0.032***
$VOLATILITY_{t-1}$	0.062***	0.034***	-0.043***	0.002	0.025***

	$INDEP_{t-1}$	$LNFIRMAGE_{t-1}$	$LNCEOAGE_{t-1}$	$LNCEOTENURE_{t-1}$	$CEOSHARE_{t-1}$
$INDEP_{t-1}$	1				
$LNFIRMAGE_{t-1}$	0.199***	1			
$LNCEOAGE_{t-1}$	0.011**	0.025***	1		
$LNCEOTENURE_{t-1}$	0.163***	0.013	0.216***	1	
$CEOSHARE_{t-1}$	0.173***	-0.382***	-0.051***	0.186***	1
GEO_{t-1}	0.359***	0.086***	0.044***	0.123***	0.179***
ROA_IND_{t-1}	0.025***	-0.160***	0.070**	0.061***	0.094***
RET_IND_{t-1}	0.011	-0.032***	-0.021**	0.029***	0.052***
$VOLATILITY_{t-1}$	0.066***	0.048***	-0.063***	-0.071***	0.010

	GEO_{t-1}	ROA_IND_{t-1}	RET_IND_{t-1}	$VOLATILITY_{t-1}$
GEO_{t-1}	1			
ROA_IND_{t-1}	0.075***	1		
RET_IND_{t-1}	0.023***	0.066***	1	
$VOLATILITY_{t-1}$	0.036***	-0.053***	0.150***	1

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$ (two-tailed tests)

Panel C: Regression results of CEO dismissal

	(1)	(2)	(3)	(4)
Dependent Variable	*Prob (DISMISSAL=1)*$_t$	*Prob (DISMISSAL=1)*$_t$	*Prob (TURNOVER=1)*$_t$	*Prob (TURNOVER=1)*$_t$
Crash Risk Variable	*NCSKEW*	*DUVOL*	*NCSKEW*	*DUVOL*
$CRASHRISK_{t-1}$	0.098**	0.134**	0.069**	0.100**
	(0.022)	(0.010)	(0.038)	(0.015)
$LNSALE_{t-1}$	-0.030	-0.030	-0.100***	-0.101***
	(0.360)	(0.352)	(0.000)	(0.000)
LEV_{t-1}	0.234	0.234	0.514***	0.514***
	(0.231)	(0.231)	(0.002)	(0.001)
$PRIVATE_{t-1}$	-0.480***	-0.481***	-0.460***	-0.460***
	(0.000)	(0.000)	(0.000)	(0.000)
$OWNER_{t-1}$	0.319	0.315	0.159	0.155
	(0.234)	(0.240)	(0.485)	(0.496)
$FOREIGN_{t-1}$	-0.154	-0.155	-0.107	-0.106
	(0.275)	(0.272)	(0.327)	(0.329)

$DUAL_{t-1}$	-0.788***	-0.786***	-0.887***	-0.885***
	(0.000)	(0.000)	(0.000)	(0.000)
$INDEP_{t-1}$	0.780	0.781	0.216	0.213
	(0.173)	(0.173)	(0.640)	(0.645)
$LNFIRMAGE_{t-1}$	0.256***	0.257***	0.265***	0.267***
	(0.005)	(0.005)	(0.000)	(0.000)
$LNCEOAGE_{t-1}$	-2.957***	-2.963***	0.183	0.177
	(0.000)	(0.000)	(0.459)	(0.473)
$LNCEOTENURE_{t-1}$	1.143***	1.141***	1.695***	1.694***
	(0.000)	(0.000)	(0.000)	(0.000)
$CEOSHARE_{t-1}$	-3.742***	-3.728***	-3.133***	-3.125***
	(0.001)	(0.001)	(0.000)	(0.000)
GEO_{t-1}	-0.122	-0.124	0.179	0.178
	(0.423)	(0.416)	(0.184)	(0.187)
ROA_IND_{t-1}	-5.281***	-5.235***	-4.943***	-4.902***
	(0.000)	(0.000)	(0.000)	(0.000)
RET_IND_{t-1}	-0.114	-0.098	-0.010	0.004
	(0.220)	(0.299)	(0.884)	(0.953)
$VOLATILITY_{t-1}$	0.304	0.306	0.416	0.424
	(0.158)	(0.154)	(0.135)	(0.144)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
pseudo R^2	0.140	0.141	0.178	0.178
N	11,835	11,835	11,835	11,835

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (two-tailed tests); p-values based on standard errors clustered by firm are displayed in parentheses.

4.3 Institutional Factors and the Sensitivity of Executive Compensation to Crash Risk

Our results thus far indicate that crash risk causes negative consequences for managers or that executives are punished for their failure to control for high crash risk through compensation reductions and an increase in their dismissal rate. In this section, we further investigate whether, and how, our results are conditioned by several important institutional governance mechanisms in China, including state ownership, the split-share reform, and the degree of provincial marketisation. To this end, we partition the full sample into the following subsamples: (1) state-owned versus non-state-owned firms; (2) before versus after the split-share reform; and (3) high versus low provincial marketisation. We then re-estimate Eqs. (1) and (2) for each subsample. The results are reported in Table 4 and summarised below.

First, we examine whether, and how, state ownership influences the association between crash risk and its negative consequences for managers. We compare the effect of crash risk on subsequent managerial compensation and CEO turnover rate in SOEs and non-SOEs. In Table 4, panels A and B report the subsample results of regressions in Eqs. (1)

and (2), respectively, where executive compensation and dismissal rate are used as the dependent variables. For brevity, we report only the results using *NCSKEW* as the test variable. In untabulated results, we find that the results using the other crash risk measure, *DUVOL*, are qualitatively the same as those using *NCSKEW*. In both panels A and B, columns 1 and 2 report the results of regressions for the subsamples of non-SOE firms and SOE firms, respectively. As shown in columns 1 and 2 of Panel A (Panel B), we find that the coefficient of *NCSKEW* is significantly negative (positive) for the SOE subsample but insignificant for the non-SOE subsample. The equality test shows that the differences between coefficients on *NCSKEW* across the SOE and non-SOE subsample are insignificant. The empirical results tend to show that executives in SOEs are more likely to be punished than executives in non-SOEs for their inability or failure to constrain crash risk below a certain threshold.

The second institutional factor we consider is the split-share structure reform in China. We expect that managerial compensation and the managerial dismissal rate become more sensitive to crash risk in the post-reform period as controlling shareholders begin to play a monitoring role in controlling crash risk. In both panels A and B of Table 4, columns 3 and 4 report the results of regressions for compensation and CEO dismissal, respectively. Although the sensitivity of managerial compensation to crash risk does not change significantly, CEO dismissal rate becomes more responsive to crash risk after the reform, indicating that in the post-reform period, controlling shareholders have more influence in decisions to replace CEOs who are unable to control high crash risk. The equality test for the difference of the coefficients on *NCSKEW* across columns 3 and 4 in Panel B of Table 4 confirms that CEOs are significantly more likely to be dismissed because of high crash risk after the reform.

Finally, we partition the sample on the basis of the degree of marketisation in the province where the firm is headquartered. We expect that firms located in more developed markets are more likely to cut compensation and dismiss executives in response to executives' inability or failure to constrain crash risk below a certain level. We measure the degree of provincial institutional development using each province's marketisation index, which is available from Fan *et al.* (2010). In panels A and B of Table 4, columns 5 and 6 report the results of regressions of executive compensation and dismissal rate in year t, respectively, on crash risk in year t-1. Consistent with H2b, we find that managerial compensation (dismissal rate) significantly decreases (increases) in the year subsequent to high crash risk for firms located in more developed markets or provinces, while the coefficients on *NCSKEW* are insignificant for firms located in less developed markets or provinces. The equality tests show a significant difference between the coefficients on *NCSKEW* across columns 5 and 6 in Panel A of Table 4, while the difference between those in Panel B of Table 4 is insignificant.

Table 4 Institutional Factors and Compensation Crash Risk Sensitivity

Panel A: Crash risk and managerial compensation

	State ownership		Split-share reform		Marketisation	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Non-SOE	SOE	Before	After	Low	High
Dependent Variable	$LNCOMP_t$	$LNCOMP_t$	$LNCOMP_t$	$LNCOMP_t$	$LNCOMP_t$	$LNCOMP_t$
$NCSKEW_{t-1}$	-0.013	-0.024***	-0.013	0.006	-0.003	-0.018**
	(0.127)	(0.001)	(0.175)	(0.294)	(0.720)	(0.018)
$LNSALE_t$	0.282***	0.262***	0.231***	0.236***	0.246***	0.250***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LEV_t	-0.442***	-0.421***	-0.318***	-0.318***	-0.247***	-0.334***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
BM_t	-0.311***	-0.296***	-0.364***	-0.119***	-0.155***	-0.246***
	(0.000)	(0.000)	(0.000)	(0.007)	(0.002)	(0.000)
$PRIVATE_t$			0.019	-0.019	0.039	-0.038
			(0.628)	(0.520)	(0.223)	(0.363)
$OWNER_t$	-0.173	-0.726***	-0.588***	-0.384***	-0.571***	-0.379***
	(0.103)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$FOREIGN_t$	0.402***	0.114**	0.266***	0.198***	0.188**	0.144***
	(0.000)	(0.026)	(0.000)	(0.000)	(0.018)	(0.009)
$DUAL_t$	0.107***	0.064	0.109*	0.064***	0.067*	0.082***
	(0.000)	(0.164)	(0.065)	(0.010)	(0.068)	(0.007)
$INDEP_t$	0.141	0.336**	0.418**	-0.104	0.112	0.067
	(0.414)	(0.016)	(0.015)	(0.431)	(0.441)	(0.668)
$LNFIRMAGE_t$	0.014	-0.000	-0.078**	-0.008	-0.036*	-0.021
	(0.535)	(0.984)	(0.014)	(0.646)	(0.099)	(0.344)
GEO_t	0.375***	0.625***	0.481***	0.516***	0.089	1.486***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.178)	(0.000)
ROA_IND_t	0.809***	1.810***	1.389***	1.860***	2.026***	1.308***
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
RET_IND_t	-0.010	0.004	-0.010	-0.017	-0.022*	-0.007
	(0.393)	(0.761)	(0.566)	(0.101)	(0.064)	(0.606)
$VOLATILITY_{t-1}$	0.070	0.230*	-0.079	0.068	0.045	0.121*
	(0.310)	(0.075)	(0.752)	(0.268)	(0.570)	(0.078)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
adj. R^2	0.545	0.657	0.459	0.473	0.648	0.586
N	7,681	9,528	5,444	11,765	9,178	8,031
p-value for $\chi 2$ test	0.152		0.040		0.070	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (two-tailed tests); p-values based on standard errors clustered by firm are displayed in parentheses; p-value for $\chi 2$ test is for difference test of coefficient of crash risk variable.

Panel B: Crash risk and CEO dismissal rate

	State ownership		Split-share reform		Marketisation	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Non-SOE	SOE	Before	After	Low	High
Dependent Variable	*Prob (DISMISSAL=1)$_t$*	*Prob (DISMISSAL=1)$_t$*	*Prob (DISMISSAL=1)$_t$*	*Prob (DISMISSAL=1)$_t$*	*Prob (DISMISSAL=1)$_t$*	*Prob (DISMISSAL=1)$_t$*
$CRASHRISK_{t-1}$	0.095	0.105**	0.016	0.141***	0.086	0.136**
	(0.256)	(0.046)	(0.847)	(0.005)	(0.125)	(0.049)
$LNSALE_{t-1}$	-0.093	0.000	-0.047	-0.017	-0.039	-0.053
	(0.101)	(0.996)	(0.512)	(0.634)	(0.356)	(0.294)

LEV_{t-1}	0.534*	-0.056	0.482	0.087	0.355	0.026
	(0.073)	(0.830)	(0.194)	(0.696)	(0.136)	(0.942)
$PRIVATE_{t-1}$			-0.384*	-0.535***	-0.335**	-0.700***
			(0.093)	(0.000)	(0.014)	(0.000)
$OWNER_{t-1}$	-0.665	0.624*	0.211	0.268	0.193	0.498
	(0.241)	(0.051)	(0.699)	(0.389)	(0.591)	(0.206)
$FOREIGN_{t-1}$	-0.566	-0.131	-0.325	-0.186	-0.006	-0.220
	(0.126)	(0.399)	(0.299)	(0.230)	(0.979)	(0.218)
$DUAL_{t-1}$	-0.627***	-0.836***	-0.390	-0.905***	-0.696***	-0.967***
	(0.001)	(0.000)	(0.147)	(0.000)	(0.000)	(0.000)
$INDEP_{t-1}$	-0.067	1.095	2.373**	0.574	0.302	0.794
	(0.948)	(0.108)	(0.029)	(0.392)	(0.664)	(0.409)
$LNFIRMAGE_{t-1}$	0.568***	0.035	0.152	0.276***	0.087	0.358**
	(0.001)	(0.748)	(0.538)	(0.006)	(0.438)	(0.015)
$LNCEOAGE_{t-1}$	-2.230***	-3.512***	-2.901***	-3.015***	-3.006***	-3.105***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$LNCEOTENURE_{t-1}$	1.051***	1.221***	1.727***	1.030***	0.958***	1.270***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$CEOSHARE_{t-1}$	-1.929	-28.910	-1805.672	-3.494***	-6.616***	-2.411*
	(0.111)	(0.268)	(0.158)	(0.001)	(0.000)	(0.089)
GEO_{t-1}	-0.082	0.015	0.002	-0.123	0.117	-1.126
	(0.741)	(0.942)	(0.994)	(0.501)	(0.620)	(0.223)
ROA_IND_{t-1}	-4.353***	-5.766***	-3.794**	-5.668***	-6.146***	-3.465**
	(0.006)	(0.000)	(0.021)	(0.000)	(0.000)	(0.015)
RET_IND_{t-1}	-0.100	-0.104	-0.093	-0.089	-0.118	-0.148
	(0.506)	(0.376)	(0.563)	(0.460)	(0.330)	(0.259)
$VOLATILITY_{t-1}$	0.230	1.186	0.294	0.137	-0.110	1.982***
	(0.281)	(0.233)	(0.576)	(0.609)	(0.806)	(0.010)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
pseudo R^2	0.184	0.103	0.157	0.144	0.127	0.164
N	5,963	5,872	1,937	9,898	6,028	5,791
p-value for $\chi 2$ test	0.458		0.092		0.289	

$*\ p < 0.1$, $**\ p < 0.05$, $***\ p < 0.01$ (two-tailed tests); *p*-values based on standard errors clustered by firm are displayed in parentheses; *p*-value for $\chi 2$ test is for difference test of coefficient of crash risk variable.

V. Additional Tests and Robustness Tests

5.1 Potential Endogeneity and Causal Inferences

Our analyses thus far show that executive compensation decreases and the dismissal rate increases in the year subsequent to high crash risk. However, it is difficult to rule out potential endogeneity concerns. Although we already include firm fixed effect in Table 2 to mitigate the concern about time-invariant omitted correlated variables, the results still face the problem of time-variant omitted correlated variables and the associated reverse causality. To further alleviate concerns about potential endogeneity, we conduct several additional tests.

5.2 Change Regression

We conduct a change regression to further alleviate concerns about potential problems of correlated omitted variables associated with the level regression and reverse causality (e.g. Bradshaw *et al.*, 2004). Specifically, we take the first difference of all continuous variables and estimate the change regression. The regression results are reported in Table 5, Panel A. We find a similar pattern to the level regression in that the coefficients on *△NCSKEW* and *△DUVOL* are both significantly negative in columns (1) and (2), respectively. Overall, the results for the change regression are consistent with those from the level regression reported in Table 2, suggesting that the results of our level regression are unlikely to be driven by correlated omitted variables and/or the associated reverse causality.

5.3 Instrumental Variable Analysis

One may argue that bad news motivates executives to hide information, which leads to future stock price crash. Meanwhile, executives take the blame for the consequence of bad news. In other words, it is the bad news itself, rather than the hoarding behaviour, that impacts executive compensation and turnover. In such a case, the single-equation OLS estimation of Eq. (1) or (2) may suffer from the endogeneity problem. To address this possibility, we introduce an instrumental variable approach and then estimate Eqs. (1) and (2) using the 2SLS procedure. In the first stage, we estimate the regression of crash risk with its determinants. In doing so, we use the removal of the short-sales constraints in China as an instrumental variable. The CSRC introduced a deregulation pilot programme of short selling in 2010. Stocks included in the programme are released from the short-selling prohibition, while other stocks remain constrained. Since 2010, one-third of the listed stocks in China have gradually been included in the pilot programme, creating both the time-series and cross-sectional variation in short-selling restrictions. Ni and Zhu (2016) find that the removal of short-sales constraints increases stock price crash risk in China, consistent with the argument that uninformed investors rush to sell when they interpret the falling stock price as being a result of informed investors short selling on negative private news, which leads to stock price crash (e.g. Ausubel, 1990; Barlevy and Veronesi, 2003). We use the regulatory changes on short-sales constraints as an exogenous shock on pilot firms' crash risk. Regulatory changes should not be related to any specific firm characteristics, such as bad news or business risk, and thus should not directly affect executives' compensation and turnover.[6]

Specifically, we construct a dummy variable (*SHORT*) which equals 1 for firm-years included in the programme and thus allowed to be shorted, and 0 otherwise. We use *SHORT* as the instrument and conduct the instrumental regression. In addition to the instrumental variable, we also control for other factors documented in the previous literature (e.g. Kim *et al.*, 2011a, 2011b) that influence crash risk, including stock turnover (*DTURNOVER*),

[6] Lu *et al.* (2018) and Ma and Tong (2019) both study the influence of the removal of short-sale constraints on compensation-performance sensitivity. However, neither of them provides any theoretical arguments or empirical evidence to support a direct influence of the removal of short-sales constraints on the level of compensation.

standard deviation of stock return (*SIGMAR*), effective tax rate (*ETR*), and earnings quality (*ACCM*), in the first stage of the 2SLS procedure. The results of the first-stage regression are reported in Panel B of Table 5. Our instrument variable, *SHORT*, is significantly associated with both crash risk measures, and the associations are significant at the 5% level. All other factors documented to influence crash risk have the expected sign.

In the second stage, we use the instrumented crash risk measures in Eqs. (1) and (2) instead of the original crash risk measures and re-estimate Eqs. (1) and (2) to test H1a and H1b, respectively. Panel C of Table 5 presents the estimated results of the second-stage regression. As shown in Panel C, we find that our main results reported in tables 2 and 3 are qualitatively similar to those of our second-stage regressions. The finding suggests that high crash risk is significantly associated with lower subsequent managerial compensation and higher CEO dismissal rate.

Table 5 Tests for Endogeneity

Panel A: Change test for managerial compensation

	(1)	(2)
Dependent Variable	$\triangle LNCOMP_t$	$\triangle LNCOMP_t$
Crash Risk Variable	$\triangle NCSKEW$	$\triangle DUVOL$
$\triangle CRASHRISK_{t-1}$	-0.007***	-0.010***
	(0.009)	(0.002)
$\triangle LNSALE_t$	0.056***	0.055***
	(0.000)	(0.000)
$\triangle LEV_t$	-0.044	-0.044
	(0.280)	(0.281)
$\triangle BM_t$	-0.055***	-0.055***
	(0.006)	(0.007)
$PRIVATE_t$	0.010*	0.009
	(0.093)	(0.136)
$\triangle OWNER_t$	0.019	0.014
	(0.814)	(0.863)
$FOREIGN_t$	0.001	0.001
	(0.932)	(0.906)
$DUAL_t$	0.022***	0.022***
	(0.002)	(0.003)
$\triangle INDEP_t$	0.140**	0.137**
	(0.039)	(0.044)
$\triangle LNFIRMAGE_t$	-0.102***	-0.093***
	(0.001)	(0.003)
$\triangle GEO_t$	0.187**	0.179**
	(0.019)	(0.024)
$\triangle ROA\_IND_t$	0.727***	0.712***
	(0.000)	(0.000)
$\triangle RET\_IND_t$	-0.007	-0.007
	(0.174)	(0.144)
$\triangle VOLATILITY_{t-1}$	0.020	-0.014
	(0.656)	(0.711)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
adj. R^2	0.047	0.047
N	14,526	14,496

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (two-tailed tests); *p*-values based on standard errors clustered by firm are displayed in parentheses.

Panel B: Instrumental variable regression – first stage

	(1)	(2)
Dependent Variable	$NCSKEW_t$	$DUVOL_t$
$SHORT_{t-1}$	0.102**	0.083**
	(0.017)	(0.016)
$CRASH\ RISK_{t-1}$	0.105***	0.126***
	(0.000)	(0.000)
$LNMV_{t-1}$	0.094***	0.083***
	(0.000)	(0.000)
LEV_{t-1}	-0.104	-0.109
	(0.275)	(0.162)
MB_{t-1}	0.017***	0.012***
	(0.000)	(0.000)
ROA_{t-1}	-0.434***	-0.403***
	(0.005)	(0.003)
$PRIVATE_{t-1}$	0.026	0.014
	(0.182)	(0.367)
$OWNER_{t-1}$	-0.197***	-0.148***
	(0.002)	(0.003)
$FOREIGN_{t-1}$	-0.116***	-0.086***
	(0.000)	(0.001)
RET_{t-1}	0.191***	0.191***
	(0.000)	(0.000)
$DTURNOVER_{t-1}$	0.048**	0.042***
	(0.011)	(0.006)
$SIGMAR_{t-1}$	1.501*	1.232**
	(0.053)	(0.049)
ETR_{t-1}	-0.062	-0.018
	(0.283)	(0.707)
$ACCM_{t-1}$	0.315**	0.201**
	(0.011)	(0.048)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
adj. R^2	0.087	0.092
N	10,914	10,911
partial F	5.72	5.81

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (two-tailed tests); p-values based on standard errors clustered by firm are displayed in parentheses.

Panel C: Instrumental variable regression – second stage

	(1)	(2)	(3)	(4)
			Prob	*Prob*
Dependent Variable	$LNCOMP_t$	$LNCOMP_t$	$(DISMISSAL=1)_t$	$(DISMISSAL=1)_t$
Crash Risk Variable	*NCSKEW*	*DUVOL*	*NCSKEW*	*DUVOL*
$CRASHRISK_{t-1}$ (Instrumented)	-0.093***	-0.106***	0.419*	0.508*
	(0.004)	(0.005)	(0.094)	(0.095)
LNSALE	0.269***	0.269***	-0.043	-0.045
	(0.000)	(0.000)	(0.225)	(0.204)
LEV	-0.278***	-0.279***	0.175	0.175
	(0.000)	(0.000)	(0.428)	(0.427)

BM	-0.244***	-0.242***		
	(0.000)	(0.000)		
PRIVATE	0.060*	0.059*	-0.502***	-0.497***
	(0.076)	(0.084)	(0.000)	(0.000)
OWNER	-0.543***	-0.541***	0.664**	0.662**
	(0.000)	(0.000)	(0.026)	(0.027)
FOREIGN	0.114**	0.116**	-0.138	-0.143
	(0.026)	(0.024)	(0.381)	(0.361)
DUAL	0.091**	0.091**	-0.689***	-0.686***
	(0.014)	(0.014)	(0.000)	(0.000)
INDEP	0.159	0.159	0.786	0.791
	(0.298)	(0.298)	(0.240)	(0.237)
LNFIRMAGE	0.228***	0.229***	0.070	0.072
	(0.000)	(0.000)	(0.684)	(0.674)
GEO	0.522***	0.523***	-0.168	-0.169
	(0.000)	(0.000)	(0.308)	(0.305)
ROA_IND	1.909***	1.901***	-5.589***	-5.573***
	(0.000)	(0.000)	(0.000)	(0.000)
RET_IND	-0.014	-0.013	-0.107	-0.107
	(0.260)	(0.276)	(0.323)	(0.325)
LNCEOAGE			-3.086***	-3.085***
			(0.000)	(0.000)
LNCEOTENURE			1.098***	1.097***
			(0.000)	(0.000)
CEOSHARE			-4.748**	-4.733**
			(0.033)	(0.033)
VOLATILITY	0.251***	0.254***	0.839	0.835
	(0.002)	(0.002)	(0.275)	(0.274)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
adj. R^2/pseudo R^2	0.491	0.491	0.104	0.104
N	9,177	9,174	7,766	7,763

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (two-tailed tests); *p*-values based on standard errors clustered by firm are displayed in parentheses. Please note that the time of the control variables are different across columns. For brevity, the time subscripts are not specified in the table. The time subscripts of control variables in columns (1) and (2) are the same as those of Panel C of Table 2, and the time subscripts of control variables in columns (3) and (4) are the same as those of Panel C of Table 3.

5.4 Contemporaneous Association

Finally, we check the contemporaneous association between executive compensation and crash risk to further rule out the potential problems of correlated omitted variables and reverse causality. Instead of using last year's estimation of crash risk, we use crash risk proxies estimated for the same period as compensation measures and re-estimate Eq. (1). If there is any reverse causality and serial correlation of crash risk, we should observe a negative correlation between contemporary crash risk and managerial compensation. We find that neither of the two proxies for crash risk are significantly associated with contemporaneous compensation (untabulated), suggesting that our main results are unlikely to be driven by reverse causality.

5.5 Alternative Measures for Managerial Compensation

We measure executives' compensation as the average annual compensation of the three highest paid executives. To further examine who takes the fall after a crash, we separately look into the compensation of CEOs and CFOs, who typically are among the three highest paid executives of firms. We use the natural logarithm of CEO compensation (*LNCOMP_CEO*) and CFO compensation (*LNCOMP_CFO*) as the dependent variables and re-estimate Eq. (1). We further control for executives' individual characteristics, including CEO/CFO age, tenure, and stock ownership, in the regressions. The results are reported in Table 6. For brevity, we do not report the coefficients on the control variables, which are qualitatively similar to those reported in Table 2. CEO compensation is significantly negatively associated with crash risk (columns 1 and 2), and CFO compensation is negatively, but insignificantly, associated with crash risk (columns 3 and 4). These results show that CEO compensation, rather than CFO compensation, drives the negative association between crash risk and executive compensation, which indicates that the CEO is the person most likely to take responsibility for high crash risk.

Table 6 Alternative Measures for Managerial Compensation

	(1)	(2)	(3)	(4)
Dependent Variable	$LNCOMP\_CEO_t$	$LNCOMP\_CEO_t$	$LNCOMP\_CFO_t$	$LNCOMP\_CFO_t$
Crash Risk Variable	*NCSKEW*	*DUVOL*	*NCSKEW*	*DUVOL*
$CRASHRISK_{t-1}$	-0.026***	-0.034***	-0.004	-0.010
	(0.007)	(0.004)	(0.657)	(0.439)
$LNCEOAGE_{t-1}$	0.192***	0.196***		
	(0.009)	(0.008)		
$LNCEOTENURE_{t-1}$	0.073***	0.072***		
	(0.000)	(0.000)		
$CEOSHARE_{t-1}$	0.221*	0.218*		
	(0.055)	(0.059)		
$LNCFOAGE_{t-1}$			-0.127*	-0.121*
			(0.067)	(0.082)
$LNCFOTENURE_{t-1}$			0.006	0.006
			(0.603)	(0.626)
$CFOSHARE_{t-1}$			-5.160	-5.908*
			(0.146)	(0.098)
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
adj. R^2	0.090	0.090	0.089	0.089
N	8,802	8,784	7,289	7,271

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$ (two-tailed tests). Control variables (same as those in Table 2) are included but not reported to save space. *p*-values based on standard errors clustered by firm are displayed in parentheses.

5.6 Crash Risk and Executive Turnover

We provide evidence that CEOs are more likely to be replaced in the years subsequent to high crash risk. Although we take out the market-wide component from the crash risk, we cannot completely rule out the possibility that high firm-level crash risk is caused by factors beyond managers' control. Then, the dismissal decision we document could be inefficient (i.e. CEOs are replaced as a scapegoat for high crash risk related to external environments out of their control rather than for high crash risk related to their misconduct or incompetence). If this is the case, high crash risk should persist even after the CEOs are forced out. To address this possibility, we compare the crash risk in the pre-dismissal period (i.e. two years before CEO dismissal) with that of the post-dismissal period (i.e. two years after CEO dismissal).

We conduct a univariate test for mean differences in crash risk between the pre- and post-dismissal period; the results are presented in Table 7. As shown in Table 7, we find that both crash risk measures (*NCSKEW* and *DUVOL*) significantly decrease from the pre- to the post-dismissal period. As for economic magnitude, the crash risk decreases by about 26% to 48% after CEO dismissal. The finding suggests that CEO dismissal in the years subsequent to high crash risk is more likely to be an efficient decision, reflecting CEOs' inability or failure to constrain for crash risk below a certain threshold level.

Table 7 Crash Risk Before and After CEO Dismissal

	Before dismissal	After dismissal	Difference
Variables	Mean	Mean	*t*-statistics
NCSKEW	-0.136	-0.171	1.327^{+}
DUVOL	-0.079	-0.117	1.766^{++}

+ $p < 0.1$; ++ $p < 0.05$; +++ $p < 0.01$ (one-tailed tests).

5.7 Crash Frequency and Executive Dismissal

Executive dismissal is not only costly to managers but also to firms. We therefore expect corporate boards and/or shareholders to be very cautious in making CEO dismissal decisions. Accordingly, one can predict that CEO dismissal is more likely to occur only after a sustained period of high crash risk, not just after a single year of high crash risk. Therefore, we examine the association between the probability of CEO dismissal and the frequency of high crash risk. To this end, we use the number of years of high crash risk during the last five years (*NO_CRASHRISK*) as a proxy for crash risk frequencies and re-estimate Eq. (2). A firm-year is considered to have high crash risk if *NCSKEW*/*DUVOL* is above the sample median. The results are reported in Table 8. For brevity, we do not report the coefficients on the control variables, which are qualitatively similar to those reported in Table 3. We find that the association between *NO_CRASHRISK* and CEO dismissal (CEO turnover) is significantly positive in both crash risk measures. As for economic effects, one more year with high crash risk during the last five years increases the dismissal rate by 9% to 13% of the average dismissal rate. The results support the idea that CEO dismissal/turnover decisions are more likely to occur after frequent high crash risk.

Table 8 Crash Frequency and Executive Dismissal

	Model 1	Model 2	Model 3	Model 4
	Prob	*Prob*	*Prob*	*Prob*
Dependent Variable	$(DISMISSAL=1)_t$	$(DISMISSAL=1)_t$	$(TURNOVER=1)_t$	$(TURNOVER=1)_t$
Crash Risk Variable	*NCSKEW*	*DUVOL*	*NCSKEW*	*DUVOL*
$NO\_CRASHRISK_{t-1}$	0.097**	0.138***	0.094**	0.111***
	(0.030)	(0.003)	(0.011)	(0.003)
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
pseudo R^2	0.105	0.106	0.127	0.128
N	6,122	6,117	6,122	6,117

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$ (two-tailed tests). Control variables (same as those in Table 3) are included but not reported to save space. *p*-values based on standard errors clustered by firm are displayed in parentheses.

VI. Conclusions

This paper investigates whether, and how, crash risk in the last year affects managerial compensation and dismissal rate in the current year. In particular, we predict and find that managerial compensation decreases and CEO dismissal rate increases after a firm experiences high crash risk. We further examine the effect of different institutional factors on compensation and dismissal efficiency and find that the negative consequences of crash risk, in terms of its impact on executives' compensation and dismissal rate, are stronger in SOEs, after the split-share reform, and in firms located in high-marketisation provinces.

The negative consequences of crash risk for executives are robust to different crash risk measures and alternative managerial compensation measures. To address concerns about potential endogeneity, we use change regression, instrumental variable analysis, and contemporaneous association tests, which help us establish the causal impact of crash risk on executives' compensation and dismissal rate. Finally, the decisions by boards to replace CEOs are efficient and justifiable, as we find that crash risk significantly decreases after their replacement.

To our knowledge, our study is one of the few, if not the first, to examine the consequences of crashes for managers and the firm, rather than the manager-specific or firm-specific determinants of crash risk. Our study provides the first set of empirical evidence that corporate boards or shareholders of public firms consider extreme negative tail risk or crash risk in executive performance evaluations. We demonstrate that executives are punished for their inability or failure to control crash risk at an appropriate level in the form of lower compensation and/or forced turnover.

A growing body of research has shown that managers increase crash risk under various incentive mechanisms and information environments (e.g. Hutton *et al.*, 2009; Jin and Myers, 2006; Kim and Zhang, 2016; Kim *et al.*, 2011a, 2011b; Xu *et al.*, 2014). Our study contributes to this burgeoning literature and helps us to complete the picture by demonstrating that managers bear the costs associated with their inability or failure to constrain undiversifiable crash risk below a certain level. Our study helps us to better understand how both incentives and monitoring together shape managerial behaviour that leads to an abrupt, large-scale decline in stock prices or crashes. Given the scarcity of empirical evidence on the consequences of crashes or crash risk, we recommend further research in this area.

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Appendix Variable Definitions

Variables	Definitions
Crash Risk Measures	
NCSKEW	Negative skewness of firm-specific weekly returns in the current year, as defined in Kim *et al.* (2011a,b)
DUVOL	Down-to-up volatility of firm-specific weekly returns in the current year, as defined in Kim *et al.* (2011a,b)
NO_CRASHRISK	Total number of years of high crash risk during the previous five years. A firm-year is classified as of high crash risk if its *NCSKEW*/*DUVOL* is above the sample median
Dependent Variables	
LNCOMP	Natural logarithm of average annual cash compensation for the top three highest paid executives
LNCOMP_CEO	Natural logarithm of annual cash compensation for CEO
LNCOMP_CFO	Natural logarithm of annual cash compensation for CFO
DISMISSAL	1 if the stated turnover reason is dismissal, litigation, personal reasons or retirement before 60 or if no reason is provided, and 0 otherwise, following Chang and Wong (2009)
TURNOVER	1 if the CEO leaves from the company and 0 otherwise
Other Variables	
LNSALE	Natural logarithm of total sales for the current year
LEV	Total liabilities divided by total assets at the end of current year
BM	Book-to-market ratio of common stockholders' equity at the end of current year
PRIVATE	1 if the firm's ultimate shareholder is a non-government entity and 0 otherwise
OWNER	Percentage of ownership held by the controlling shareholder
FOREIGN	1 for firms issuing H-shares or B-shares and 0 otherwise
DUAL	1 for firms in which CEO is also chair director and 0 otherwise
INDEP	Percentage of independent directors on the board
LNFIRMAGE	Natural logarithm of number of years after IPO
GEO	Natural logarithm of market index for the province or provincial level region (from Fan *et al.*, 2010)
ROA_IND	The ROA minus the industry mean ROA
RET_IND	The stock return minus the industry mean stock return
VOLATILITY	Standard deviation of firm-specific weekly returns over the fiscal year
LNCEOAGE	Natural logarithm of CEO age
LNCEOTENURE	Natural logarithm of number of years that the CEO has been in the position
CEOSHARE	Shares owned by CEO divided by outstanding shares
LNCFOAGE	Natural logarithm of CFO age
LNCFOTENURE	Natural logarithm of number of years that the CFO has been in the position
CFOSHARE	Shares owned by CFO divided by outstanding shares
SHORT	1 for firm-years in which the firm is included in the pilot list and allowed for shorting and 0 otherwise
LNMV	Natural logarithm of market value of company at the end of year
ROA	Net income before extraordinary items scaled by the beginning balance of total assets
RET	Annual market-adjusted stock returns during the current fiscal year
DTURNOVER	The detrended average monthly stock turnover in year t
SIGMAR	The standard deviation of stock return in year t
ETR	The effective income tax rate in year t
ACCM	The three-year moving sum of absolute discretionary accruals, where discretionary accruals are estimated from the modified Jones model